Borehole and Ice Feature Annotation Tool

User Manual

Version 1.0

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Introduction

Borehole and Ice Feature Annotation Tool aids in the annotation and classification of borehole features, including layers, clusters and inclusions. It works with optical televiewer images of glacier borehole images.

1 Installation

The standalone version of Borehole and Ice Feature Annotation Tool requires no installation. To start the software open the file "FeatureAnnotationTool.exe" in the program folder.

There are a number of required library files also located in this folder. If any of these are moved or deleted, or if the "FeatureAnnotationTool.exe" file is moved, parts of the software will not function correctly.

2 Getting started

2.1 Projects

Each project creates a folder where all files relating to the annotation are located. There are three options available for creating a new project: Create a new borehole project from a bitmap file, create a new ice core project from a bitmap file and create a new project from *.HED/*.otv files.
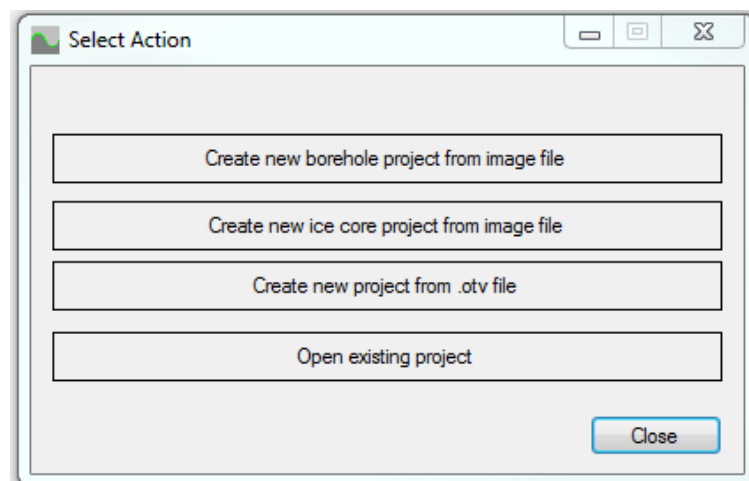

Figure 1 The project selection dialog box

2.1.1 Create a new borehole/core project from a bitmap

There are a number of ways this type of project can be created. When the software is initially opened either the 'Create new borehole project from image file' or the 'Create new ice core project from image file' button can be selected from the project action dialog box (Figure 1). It is also possible to create this project type from the menu by choosing 'File>New>From Image>' and either 'Borehole image' or 'Core image'. Similarly, the 'New' icon can be clicked from the menu bar and 'From image>' then 'Borehole image' or 'Core image' selected.

Once this has been selected an open file dialog box will appear. Locate and highlight the relevant bitmap file and click the 'Open' button.
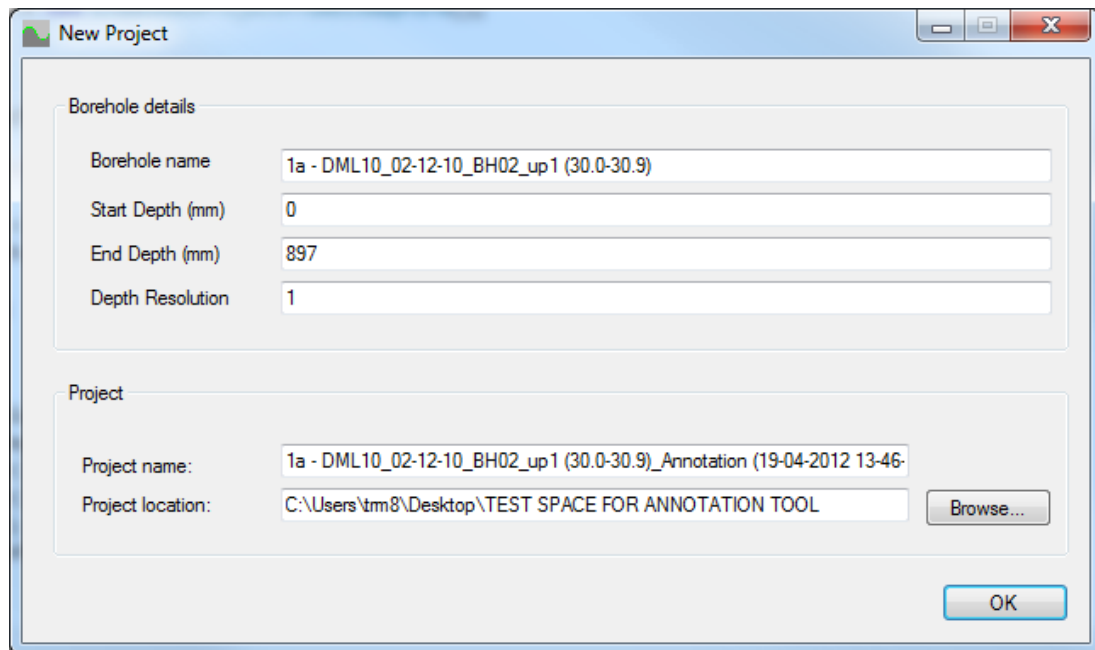

Figure 2 New Project from image dialog box

A new dialog box will open (Figure 2). The text fields are automatically populated using details from the selected bitmap.

Borehole/core name - This is set to the same as the bitmap file title, although this can be changed to any value.

Start depth (mm) - This is set to 0. It can be set to any valid integer value, positive or negative. When this value is changed the 'end depth' value is automatically updated.

End depth (mm) - This is set to the height of the image in pixels. It can be set to any valid integer value, positive or negative. When this value is changed the 'start depth' value is automatically updated.

Depth Resolution - this defines the resolution of the image in mm per pixels and is automatically set to 1. This can be changed to any positive integer value. The value of 'end depth' will automatically be updated to reflect this change.

Project name - This defines the name of the project folder and is set to '[Bitmap file title]_Annotation ([date])'. This can be changed to any value that does not contain any invalid filename characters \ / : * ? " < > |.

Project Location - This shows where the project folder will be located. It's default value is the location of the selected borehole image but it can be changed to any valid folder location. Alternatively by clicking the 'Browse...' button a location can be selected using a folder selection dialog box.

Once the correct values have been entered click on the 'OK' button to load the image into the project.

2.1.2 Create a new project from otv/hed files

There are a number of ways this type of project can be created. When the software is initially opened the 'Create new file from .otv file' button can be selected from the project action dialog box (Figure 1). It is also possible to create this project type from the menu by choosing 'File>New>From otv/hed>' or, similarly, the 'New' icon ☐▾ can be clicked from the menu bar and 'From otv/hed >' selected.

Once this has been selected an open file dialog box will appear. Locate and highlight the relavent '.hed' file, ensuring that the corresponding '.otv' file is in the same folder.
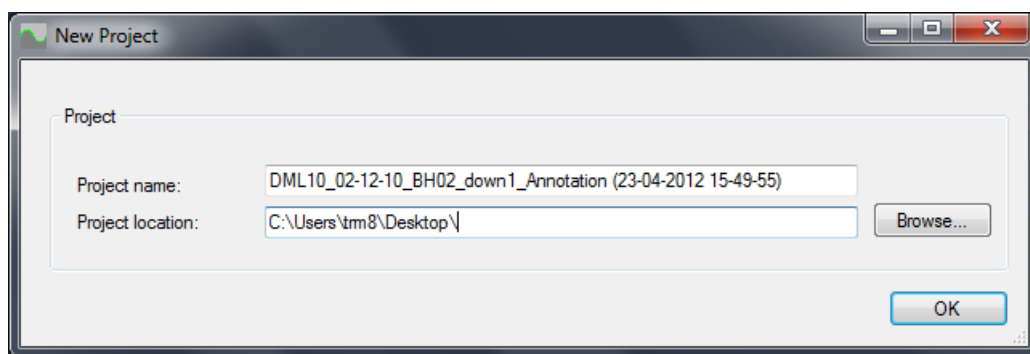

Figure 3 New project from otv/hed file dialog box

A new dialog box will open (Figure 3). The text fields are automatically populated using details from the selected files.

Project name - This defines the name of the project folder and is set to '[hed file title]_Annotation ([date])'. This can be changed to any value that does not contain any invalid filename characters **\ / : * ? " < > |**.

Project Location - This shows where the project folder will be located. Its default value is the location of the selected file but it can be changed to any valid folder location. Alternatively by clicking the 'Browse…' button a location can be selected using a folder selection dialog box.

When creating a project from an otv/hed file there is no need to enter details such as the borehole name, the start and end depths, and resolution as these values are taken from the .hed header file.

2.1.3 Open existing project

An existing project can be opened by selecting the 'Open existing project' button from the project action dialog box (Figure 1). Alternatively, an existing project can be opened choosing the menu option 'File>Open>' or by selecting the 'Open' icon ☐ from the menu bar. An open dialog box will appear and the relevant '.features' file can be selected. Alternatively, the '.features' file can be

double clicked from out with the Feature Annotation Tool and the software will be launched and the current project opened.

3   Annotating Features

3.1   General

3.1.1   Borehole/Core Details

To view details of the current project select "Tools>Borehole details" or "Tools>Core details. This will open a window displaying the details of the project (Figure 4).
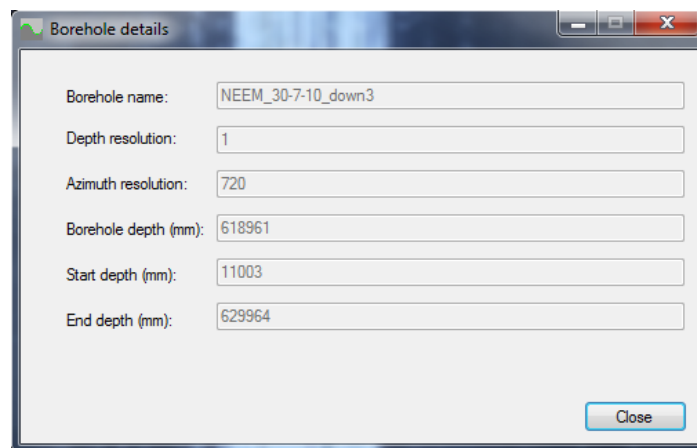

Figure 4 The Borehole details window

The details that are displayed are:

Borehole/Core name - This gives the name of the borehole or core. The default value is the name of the file if the project was created from an image, and can be changed when creating the project. If the project was created from an otv file the borehole name is taken from the header file and can not be altered.

Depth resolution – This defines the vertical resolution of the image in millimetres per pixel. This is set manually when creating a new project from an image, and is automatically read from the header file when creating a new project from an otv file.

Azimuth Resolution – This defines the boreholes horizontal resolution. In a borehole image it describes how many pixels were captured at every row down the borehole.

Borehole/Core depth (mm) – This gives the total depth of the borehole or core in millimetres.

Start depth (mm) – This gives the start depth of the borehole or core in millimetres.

End depth (mm) – This gives the end depth of the borehole or core in millimetres.

3.1.2   Options

A number of options can be configured from the menu bar.

3.1.2.1   Auto save project

By default, every change that is made to your annotation automatically saves so that there is no need to manually save regularly. To turn this off, on the menu bar select "Options>Auto save project"

3.1.2.2   Show/hide features

Once features have been added, either manually or automatically, there is an option to hide them in order to view the borehole/core image. To show or hide features select the "Show features" tick box below the Features buttons box (Figure 5).
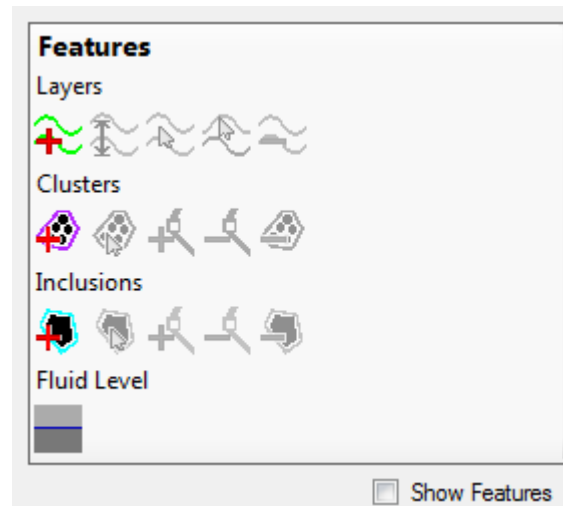
Figure 5 The features buttons box and the show/hide features tick box

3.2   Layers

Layers are the main feature which can be annotated with the feature annotation tool. In borehole projects layers appear as sinusoids (Figure 6) and in core projects they can be added as straight, sloped lines.
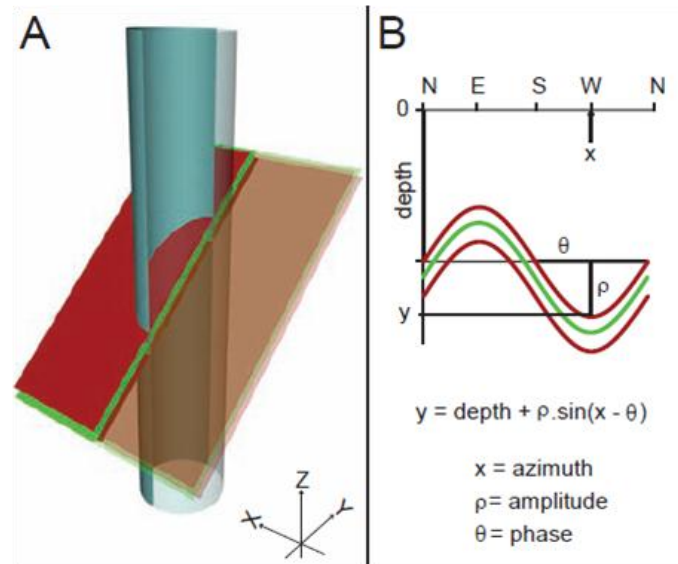
Figure 6 Image illustrating how a layers intersect a borehole (A) and how they appear on the unrolled image (B)

3.2.1 Automatic layer detection

To begin automatic layer detection select 'Automatic detection>Detect layers' from the menu. The automatic layer detection parameters dialog box will appear. Initially, the box is set to simplified parameters. This allows for more general settings to be applied. In advanced mode there are more parameters to modify, giving more control.

3.2.1.1 Simplified mode
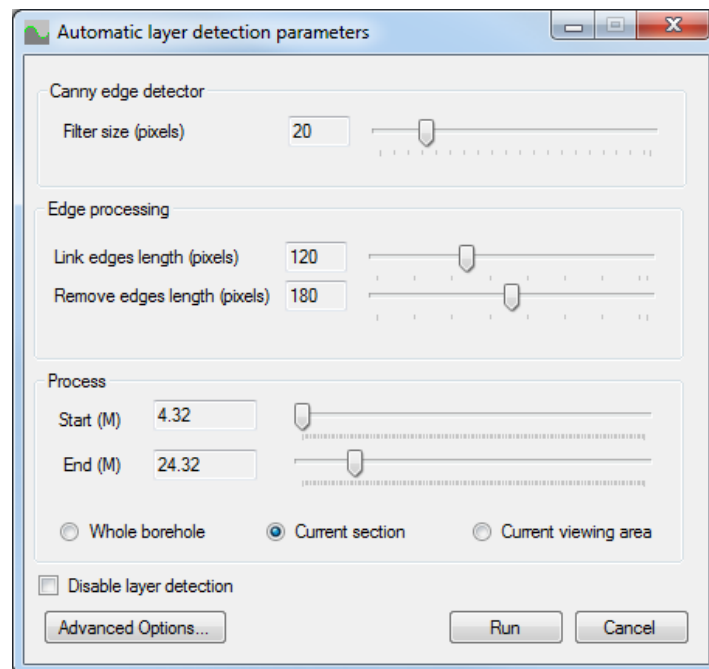
Figure 7 Automatic layer detection parameters in 'simplified' mode

3.2.1.1.1 Canny Edge Detector

The Canny edge detector deals with finding edges in the image. There are four parameters for this, two dealing with the filter size and two with thresholds for determining when an edge is considered strong enough.

In 'simplified' mode, only one parameter relating to the edge detector can be edited:

> **Filter size (pixels) -** This determines the width of the filter. The sigma value of the filter will automatically be set to a third of the chosen value. The two threshold values are automatically set to values which generally perform well.

3.2.1.1.2 Edge Processing

Once edges have been detected they are then processed in order to determine if they belong to actual layers as opposed to other artefacts. Edges are grouped together based on their position and size and kept only if they meet certain criteria. In 'simplified' mode two edge processing options can be altered:

> **Link edges length (pixels) –** This determines how many pixels long an edge must be before it is considered for linking with other, smaller edges.

> **Remove edges length (pixels) –** This determines how many pixels long an edge must be in order for it not to be discarded.
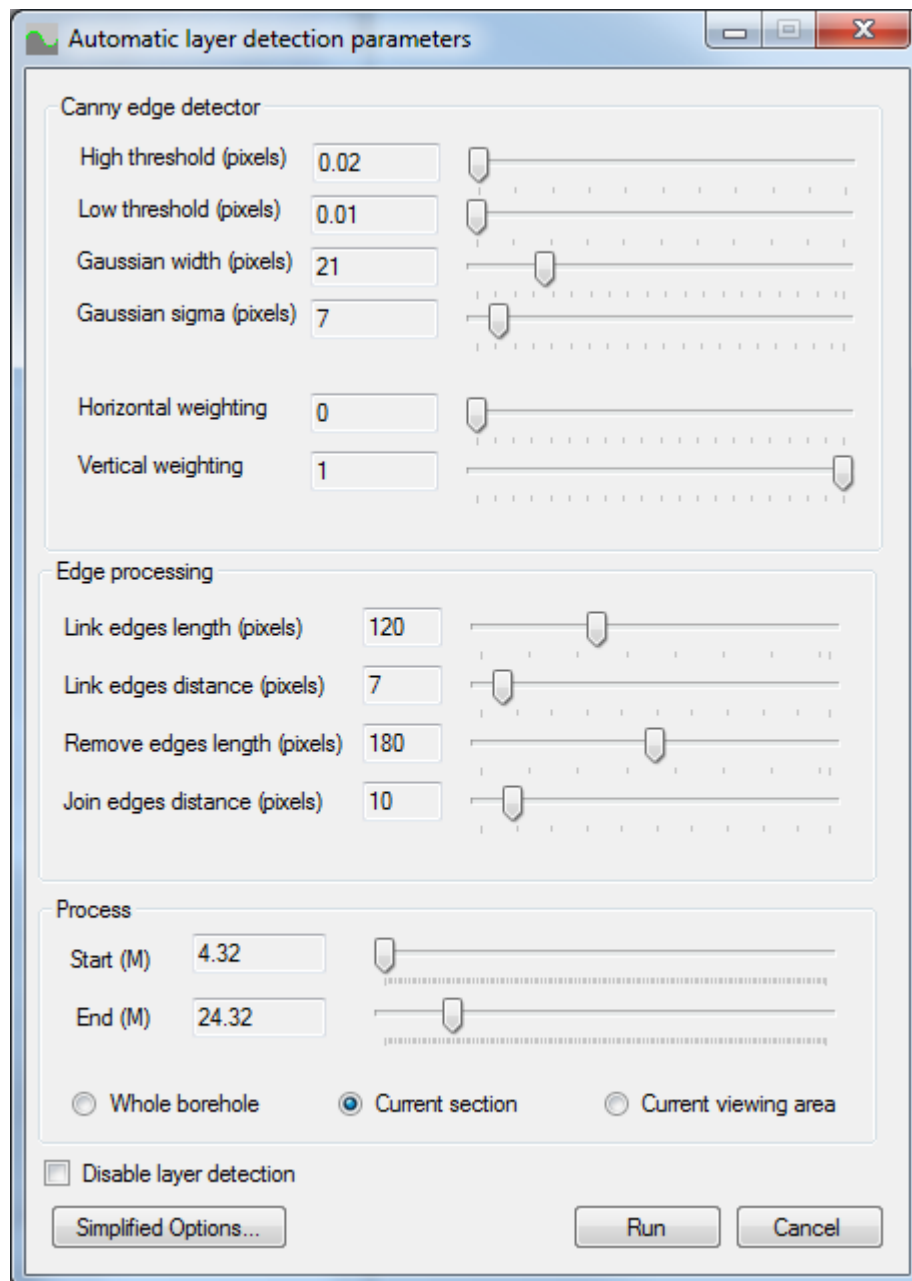
3.2.1.2 Advanced mode

Figure 8 Automatic layer detection parameters in 'advanced mode'

3.2.1.2.1 Canny Edge Detector

The Canny edge detector deals with finding edges in the image. There are four parameters for this, two dealing with the filter size and two with thresholds for determining when an edge is considered strong enough.

High threshold (pixels) – The high threshold of the feature determining how strong an edge must be.

Low threshold (pixels) – The low threshold of the feature determining how strong an edge must be.

Gaussian width (pixels) – This determines the width and height, in pixels, of the Gaussian filter used.

Gaussian sigma (pixels) – This determines the size of the sigma value, in pixels, of the Gaussian filter used.

3.2.1.2.2   Edge Processing

Once edges have been detected they are then processed in order to determine if they belong to actual layers as opposed to other artefacts. Edges are grouped together based on their position and size and kept only if they meet certain criteria. In 'advanced' mode four edge processing options can be altered:

Link edges length (pixels) – This determines how many pixels long an edge must be before it is considered for linking with other, smaller edges.

Link edges distance (pixels) – This determines how close, in pixels, the ends of edges should be to be considered for linking.

Remove edges length (pixels) – This determines how many pixels long an edge must be in order for it not to be discarded.

Join edges distance (pixels) – This determines how close, in pixels, the ends of edges must be in order to be considered for joining.

3.2.1.3   Processing options

The 'Process' section sets the start and end depth of the section to be automatically processed. By sliding the two scrollbars the start and end depth can be changed. Alternatively, there are three radio buttons which can be used to automatically set the depths:

Whole borehole – The entire borehole is processed.
Current section – The current section that is being viewed is processed.
Current viewing area – The area in the current window is processed.

3.2.1.4   Disable layer detection

As well as detecting edges automatic feature detection attempts to group found edges together as layers. The current version of this works well on some images but on others, particularly where contrast is low, results are less than desirable. Tick this box if you would like to just run automatic edge detection, leaving layer grouping to be carried out manually.

When all of the relevant options have been selected press the 'Run' button. A dialog box will pop-up asking if you wish to "Remove previously annotated layers?" This option removes any layers which have already been annotated, manually or automatically, in the section to be processed.

3.2.2   Manual annotation

On a borehole project layers can be annotated as sinusoids, and on a core project they are annotated as sloped lines.

3.2.2.1 *Borehole Image*

3.2.2.1.1 Adding a layer

Layers can be annotated by selecting the 'Add layer' button , then clicking two points, the highest and lowest, along one of its edges ('Point 1' and 'Point 2' from Figure 9a). A sinusoid will then be drawn on the image (Figure 9b).
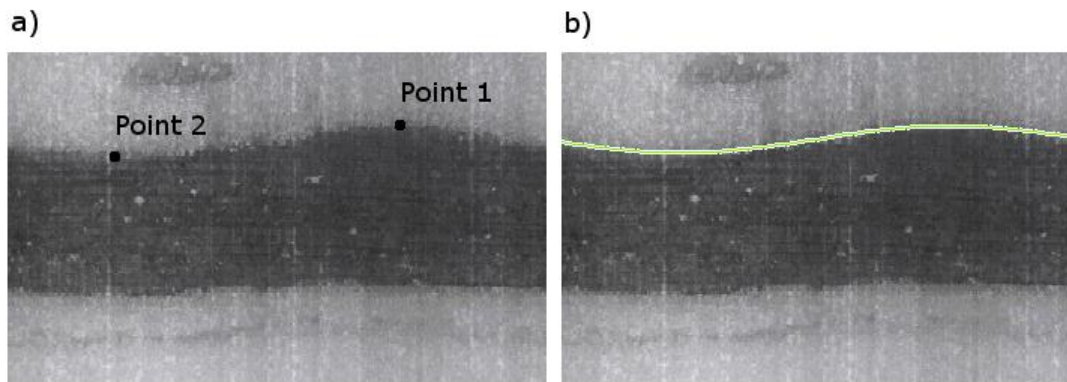

Figure 9 Adding a layer to a borehole image. (a) Left-click two points along the edge. (b) A sinusoidal line will be automatically drawn onto the image.

If a layer consists of more than one edge, this can be annotated by either drawing the other edge and joining the two or by using either the 'Alter thickness of layer' (section 3.2.2.1.2) or 'Alter one edge of layer' (section 3.2.2.1.3) button.

3.2.2.1.2 Altering layer thickness

With a layer selected, left-click the 'Alter thickness of layer' button . By holding down the left mouse button and dragging either of the edges up or down the layer thickness can be altered.

3.2.2.1.3 Altering a layer

The 'Alter layer' button allows a layer to be moved, and its amplitude changed. When a layer is selected the 'Alter layer' button is automatically activated, otherwise it can be selected by left-clicking the button. To move the layer hover the mouse pointer over the layer until it changes to the 'move' icon then hold down the left mouse button and drag to move the vertical and horizontal position of the layer. To change the layers amplitude hover the mouse pointer over the lowest point of the sinusoid until it changes to the ' north-south' icon then hold down the left mouse button and drag either up or down to alter the amplitude.

3.2.2.1.4 Altering one edge of layer

The 'Alter one edge of layer' button allows for the one edge of a multi edge layer to be moved, and its amplitude altered. To alter one edge of a layer left-click the 'Alter one edge of layer' button and follow the steps in section 3.2.2.1.3, above.

3.2.2.1.5 Deleting a layer

When a layer is selected it can be deleted by left-clicking the 'Delete layer' button , pressing the 'Delete' key on the keyboard or right-clicking the layer and selecting 'Delete'.

3.2.2.1.6 Joining and splitting a layer

Once automatic layer detection has been carried out, or in the course of manually annotating layers, some annotated edges may need to be combined to form layers (Figure 10), or layers split to form individual edges.
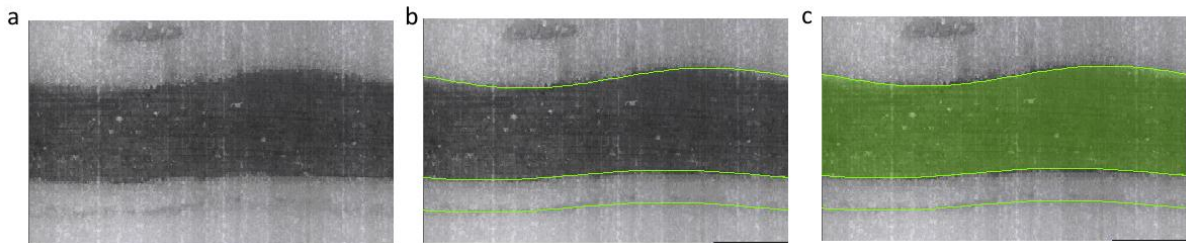

Figure 10 Image showing the joining of layers. (a) The original image. (b) The image with annotated layers. (c) The image after the top two layers are merged into one.

Joining - To join two edges together first left-click to select one of the edges then, while holding down the 'control' key, left-click the layer it is to be joined to. These edges will be joined to form one layer. The end layer will take the properties of the first selected edge.

Splitting – With a layer selected hold down the 'shift' key and left-click anywhere in the layer. This will split the layer into two separate one edge layers with both taking the properties of the original layer.

3.2.2.2 Core Image

A core layer differs from a borehole layer in that it's edges are represented by a sloped line rather than a sinusoid.

3.2.2.2.1 Adding a layer

To add a layer to a core image select the 'Add layer' button , then left-click two points along the edge. For best results select points that are far apart (Figure 11). A sloped line will be annotated onto the core image.
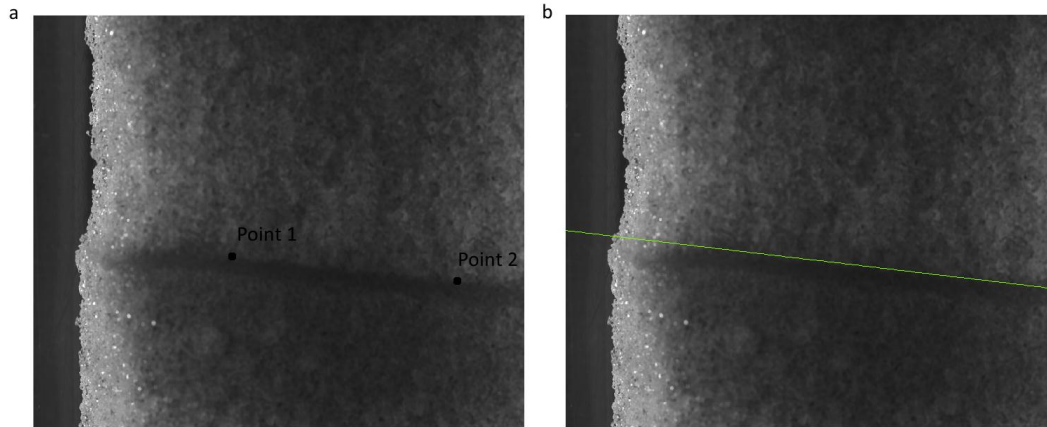
Figure 11 Adding a layer to a core image. (a) Left-click two points along the line. (b) A sloped line will be automatically drawn onto the image.

If a layer consists of more than one edge, this can be annotated by either drawing the other edge and joining the two or by using either the 'Alter thickness of layer' (section 3.2.2.2.2) or 'Alter one edge of layer' (section 3.2.2.2.3).

3.2.2.2.2   Altering layer thickness

With a layer selected, left-click the 'Alter thickness of layer' button . Hold down the left mouse button and drag either of the edges up or down the layer thickness can be altered.

3.2.2.2.3   Altering a layer

In a core image the 'Alter layer' button allows a layer to be moved. When a layer is selected the 'Alter layer' button is automatically activated, otherwise it can be selected by left-clicking the button. To move the layer hover the mouse pointer over the layer until it changes to the 'move' icon then hold down the left mouse button and drag to move the vertical and horizontal position of the layer. Altering one edge of layer

The 'Alter one edge of layer' button allows for the one edge of a multi edge layer to be moved. To alter one edge of a layer left-click the 'Alter one edge of layer' button and follow the steps in section 3.2.2.1.3, above.

3.2.2.2.4   Deleting a layer

When a layer is selected it can be deleted by left-clicking the 'Delete layer' button , pressing the 'Delete' key on the keyboard or right-clicking the layer and selecting 'Delete'.

3.2.2.2.5   Joining and splitting a layer
Once automatic layer detection has been carried out, or in the course of manually annotating layers, some annotated edges may need to be combined to form layers (Figure 12), or layers split to form individual edges.
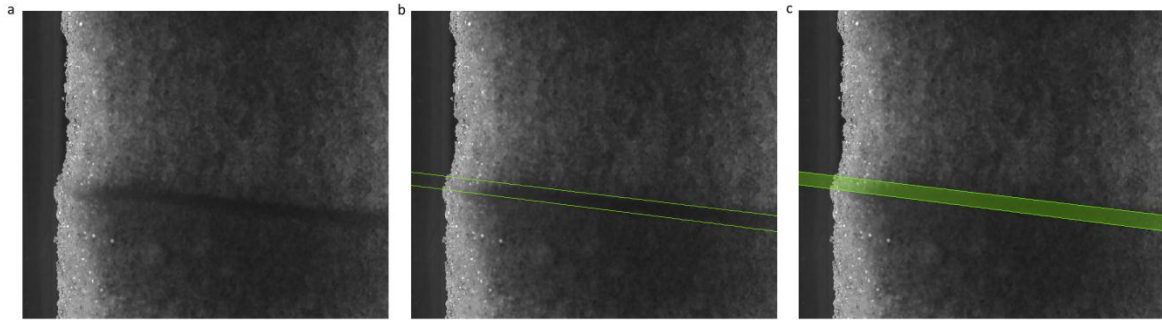
Figure 12 Image showing the joining of layers. (a) The original image. (b) The image with annotated layers. (c) The image after the top two layers are merged into one.

Joining - To join two edges together first left-click to select one of the edges then, while holding down the 'control' key, left-click the layer it is to be joined to. These edges will be joined to form one layer. The end layer will take the properties of the first selected edge.

Splitting – With a layer selected hold down the 'shift' key and left-click anywhere in the layer. This will split the layer into two separate one edge layers with both taking the properties of the original layer.

3.2.3   Layer properties

A number of the layer's properties are displayed in BIFAT's layer properties bar (Figure 13). Some of these can be altered by the user while others are fixed and can only be changed by direct manipulation of the layer itself.

Figure 13 The layer properties bar

3.2.3.1 Fixed properties

3.2.3.1.1 Borehole layer properties

Depth

> **Start Depth (mm) –** The depth of the start of the layer in millimetres (Not to be confused with the depth of each edge in the layer).
>
> **End Depth (mm) –** The depth of the end of the layer in millimetres.

Top Edge

> **Amplitude –** The amplitude (half the height) of the top edge of the layer in millimetres.
>
> **Azimuth –** The orientation of the top edge in degrees (0-360). The azimuth point is the lowest point (or trough) of the edge.
>
> **Depth (mm) –** The depth of the top edge in millimetres.

Bottom Edge

> **Amplitude –** The amplitude (half the height) of the bottom edge of the layer in millimetres.
>
> **Azimuth –** The orientation of the bottom edge in degrees (0-360). The azimuth point is the lowest point (or trough) of the edge.
>
> **Depth (mm) –** The depth of the bottom edge in millimetres.

3.2.3.1.2 Core layer properties

Depth

Start Depth (mm) – The depth of the start of the layer in millimetres (Not to be confused with the depth of each edge in the layer).

End Depth (mm) – The depth of the end of the layer in millimetres.

Top Edge

Intercept (mm) – The depth, in millimetres, where the top edge intersects the y axis.

Slope – The slope of the top edge.

Bottom Edge

Intercept (mm) – The depth, in millimetres, where the bottom edge intersects the y axis.

Slope – The slope of the bottom edge.

3.2.3.2 Variable properties

A number of the layer's properties can be directly edited in the properties bar. These are optional and can be left at the default values.

Description – A string of text describing the layer.

Group - The group the layer belongs to (see section 3.2.4 Layer groups for further information).

Quality – The visibility of the layer (1-very poor, 4-very clear).

Layer Type – A number of values can be set to true or false, depending on whether the layer contains the listed material. These are 'Clean', 'Coarse debris', 'Diamicton', 'Fine debris', 'Large bubbles', 'Small bubbles' and 'Void'.

3.2.4 Layer groups

Layers can be categorised as belonging to different groups, making performing later analysis on them easier. When a layer is created it is automatically classed as belonging to the group 'Unspecified'.

There are two ways to add a new group. The first is to type a new group name in the layer's property grid box. The second way is to open the Layer groups dialog box (Figure 14) by selecting 'Features>Layers>Groups' from the menu strip. From here press the 'Add group' button and a dialog box will appear where the new group name can be entered.
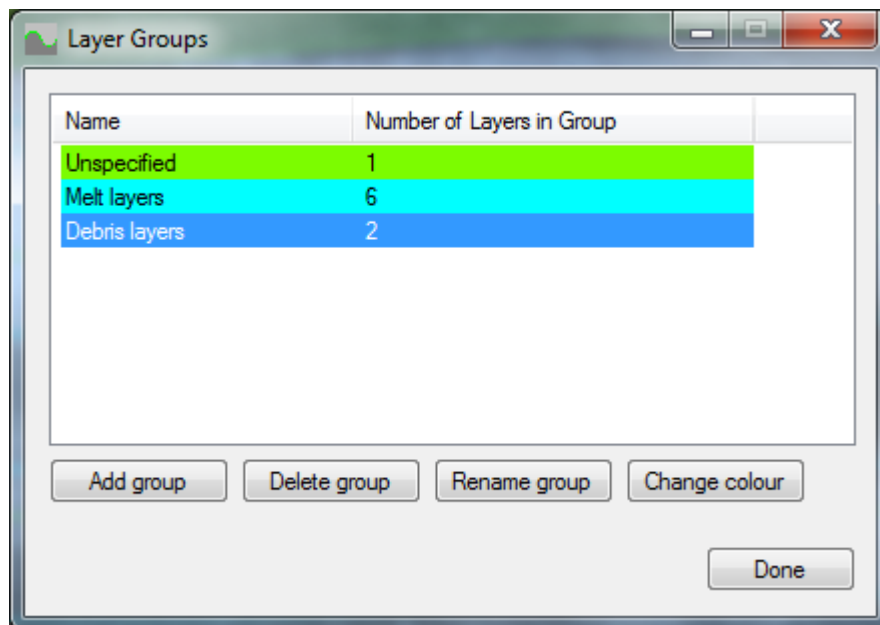
Figure 14 The Layer groups dialog box

A number of other actions can be carried out using the Layer groups box.

> **Delete group –** This button will delete the selected group. Any layers belonging to this group will be added to the 'Unspecified' group. 'Unspecified' cannot be deleted since there must always be at least one group.

> **Rename group –** This allows the renaming of a group after creation. The 'Unspecified' group cannot be renamed.

> **Change colour –** The colour that each group's layers are, both in the Feature Annotation Tool and when exported as images can be changed here.

The group a layer belongs to can be changed in the layer's property grid or by right-clicking on the layer and selecting 'Select Group' and the group you wish to move it to.

3.3 Clusters

3.3.1 Adding a cluster

Clusters can be manually annotated onto the image by selection the 'Add Cluster' button , and left-clicking points around the cluster. To finish annotating the cluster left-click the first point again. This will close the annotated shape (Figure 15).
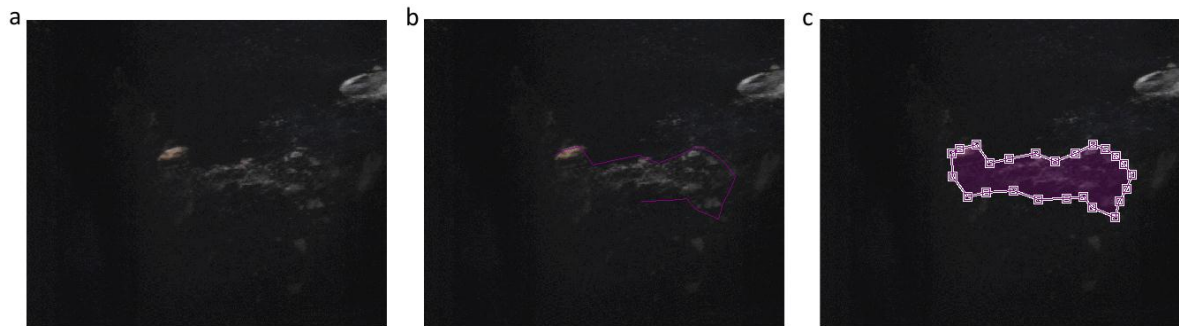
Figure 15 Adding a cluster. (a) The original image. (b) Adding the cluster. (c) Completed cluster.

3.3.2 Editing a cluster

The 'Edit Cluster' button ⬡ allows for the repositioning of the entire annotated cluster or individual added points. Once a cluster has been added the 'Edit Cluster' button is automatically selected, otherwise it can be selected by left-clicking the button. To reposition the entire annotated cluster hold down the left mouse button anywhere within the shaded area and drag the shape to the desired location. To alter any of the individual cluster points hold down the left mouse button within the square (Figure 15c) and drag the point to the desired location.

3.3.3 Adding a point to a cluster

Once a cluster has been annotated additional points can be added by selecting the 'Add Point to Selected Cluster' button ⬡ and left-clicking on, or close to, the line surrounding the cluster shape.

3.3.4 Removing a point from a cluster

Once a cluster has been annotated points can be removed by selecting the 'Remove Point from Selected Cluster' button ⬡ and left-clicking the square surrounding the point to be removed. Note that there can be no less than three points representing a cluster.

3.3.5 Deleting a cluster

When a cluster is selected it can be deleted by left-clicking the 'Delete Cluster' button ⬡, or pressing the 'Delete' key on the keyboard.

3.3.6 Cluster properties

A number of the cluster's properties are displayed in BIFAT's properties bar (Figure 16). Some of these can be altered by the user while others are fixed and can only be changed by direct manipulation of the cluster itself.
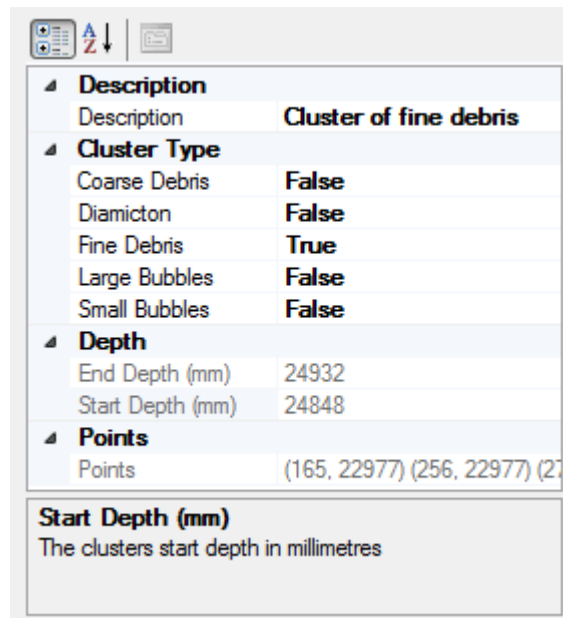
Figure 16 The Cluster properties bar

3.3.6.1 Fixed properties

Depth

    Start Depth (mm) – The depth of the start of the cluster in millimetres.

    End Depth (mm) – The depth of the start of the cluster in millimetres.

Points

    The points joining the cluster's edges.

3.3.6.2 Variable properties

Description – A string of text describing the cluster.

Cluster Type – A number of values can be set to true or false, depending on whether the cluster contains the listed material. These are 'Coarse debris', 'Diamicton', 'Fine debris', 'Large bubbles' and 'Small bubbles'.

3.4 Inclusions

3.4.1 Adding an inclusion

Inclusions can be manually annotated onto the image by selection the 'Add Inclusion' button , and left-clicking points around the inclusion. To finish annotating the inclusion left-click the first point again. This will close the annotated shape (Figure 17).
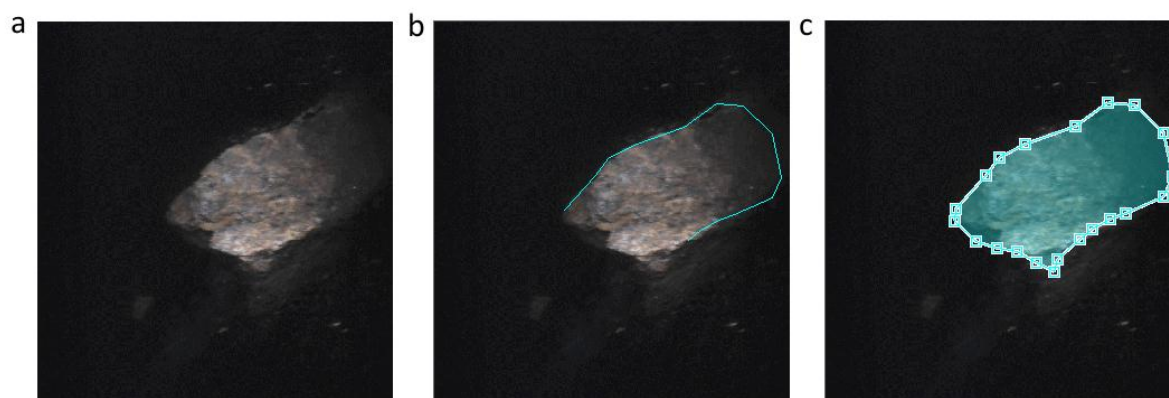

Figure 17 Adding an inclusion. (a) The original image. (b) Adding the inclusion. (c) Completed inclusion.

3.4.2 Editing an inclusion

The 'Edit Inclusion' button allows for the repositioning of the entire annotated inclusion or individual added points. Once an inclusion has been added the 'Edit Inclusion' button is automatically selected, otherwise it can be selected by left-clicking the button. To reposition the entire annotated inclusion hold down the left mouse button anywhere within the shaded area and drag the shape to the desired location. To alter any of the individual inclusion points hold down the left mouse button within the square (Figure 17c) and drag the point to the desired location.

3.4.3 Adding a point to an inclusion

Once an inclusion has been annotated additional points can be added by selecting the 'Add Point to Selected Inclusion' button and left-clicking on, or close to, the line surrounding the inclusion shape.

3.4.4 Removing a point from an inclusion

Once an inclusion has been annotated points can be removed by selecting the 'Remove Point from Selected Inclusion' button and left-clicking the square surrounding the point to be removed. Note that there can be no less than three points representing an inclusion.

3.4.5 Deleting an inclusion

When an inclusion is selected it can be deleted by left-clicking the 'Delete Inclusion' button , or pressing the 'Delete' key on the keyboard.

3.4.6 Inclusion properties

A number of the inclusion's properties are displayed in BIFAT's properties bar (Figure 18Figure 16). Some of these can be altered by the user while others are fixed and can only be changed by direct manipulation of the inclusion itself.
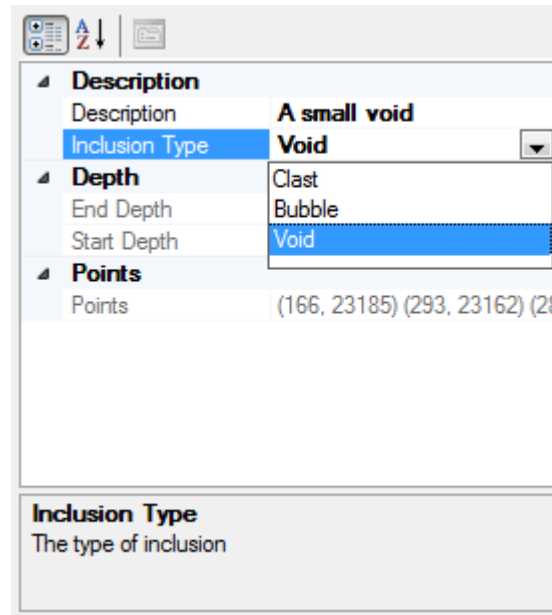
Figure 18 The inclusion properties bar

3.4.6.1 Fixed properties

Depth

    Start Depth (mm) – The depth of the start of the inclusion in millimetres.

    End Depth (mm) – The depth of the start of the inclusion in millimetres.

Points

    The points joining the inclusion's edges.

3.4.6.2 Variable properties

Description – A string of text describing the inclusion.

Inclusion Type – A drop down box gives the option of selecting either 'Clast', 'Bubble' or 'Void'.

4 Outputs

4.1 Export image

The image currently being worked on can be exported as a bitmap, with a number of different options. The image can be exported with or without the features drawn on, with the option of adding a ruler (Figure 19). To export an image, from the menu bar select 'Tools>Export image' and select the options based on whether to show the features and ruler.
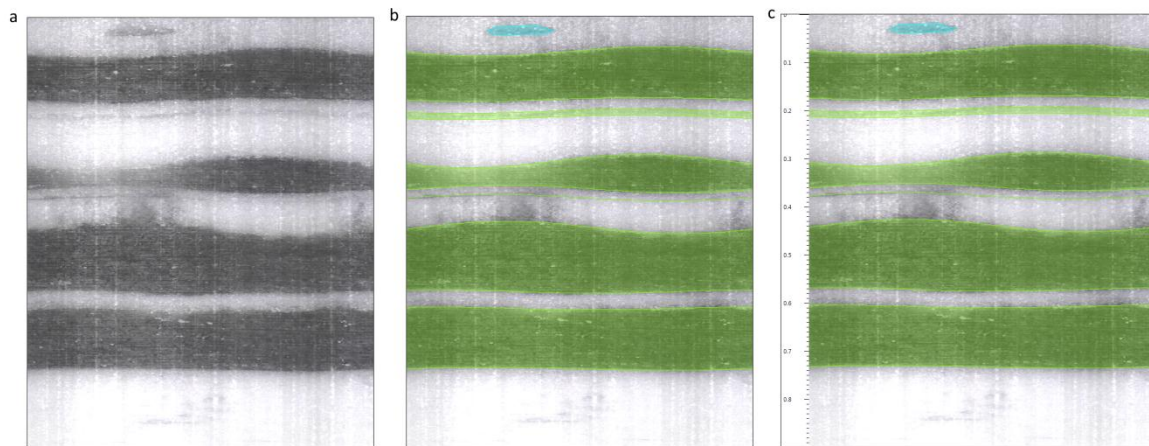
Figure 19 Results of exporting a borehole image. (a) Without features and ruler. (b) With features and no ruler. (c) With features and ruler.

4.2 Export features

The details of features which have been annotated onto the image can be exported to either a text or an excel file. To do this, from the menu bar, select 'Features' and either 'Export to excel' or 'Export to text file', then select which features to export. If selecting to export to excel the option of exporting all features is available, saving layers, clusters and inclusions to separate worksheets. Once a selection has been made a window will open, allowing for the selection of which of the features' details are to be exported (Figure 20, Figure 21 and Figure 22). For a detailed description of each of the details see sections 3.2.3 - Layer properties, 3.3.6 - Cluster properties and 3.4.6 - Inclusion properties for layers, clusters and inclusions respectively.

If selecting to export layer details the option of exporting mean layer brightness is available. This option calculates the mean brightness between the edges of two-edge layers, on a scale of 0-255,with 0 bwing black and 255 being white. Note that in an image with a number of layers selecting this option may cause the writing of the file to take a long time.
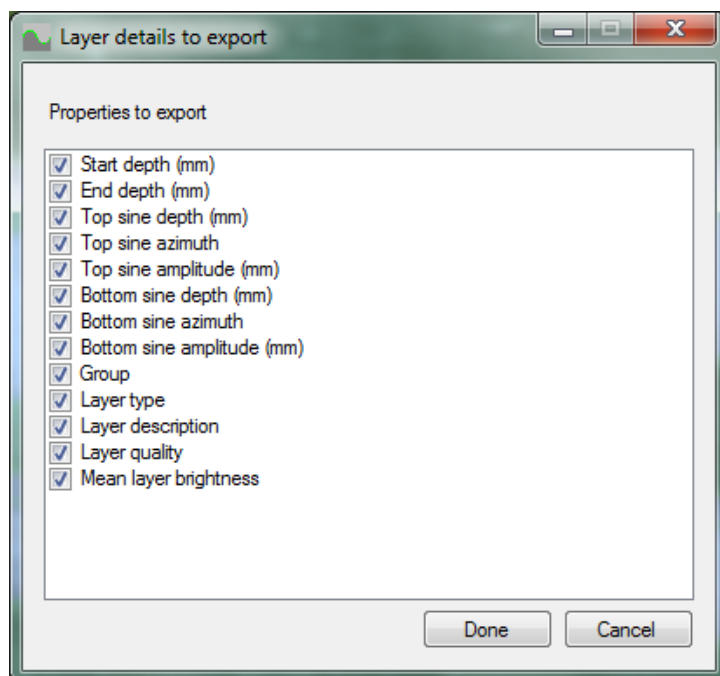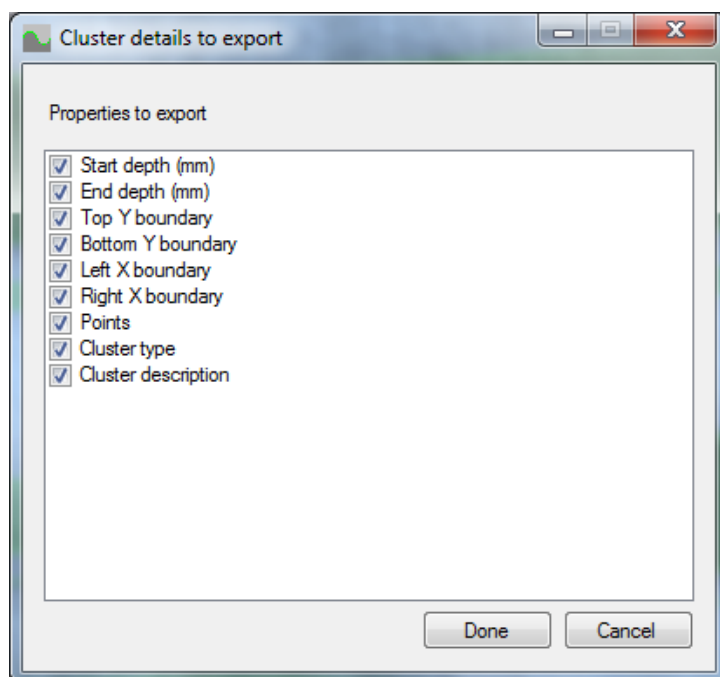
Figure 20 Layer details to export.

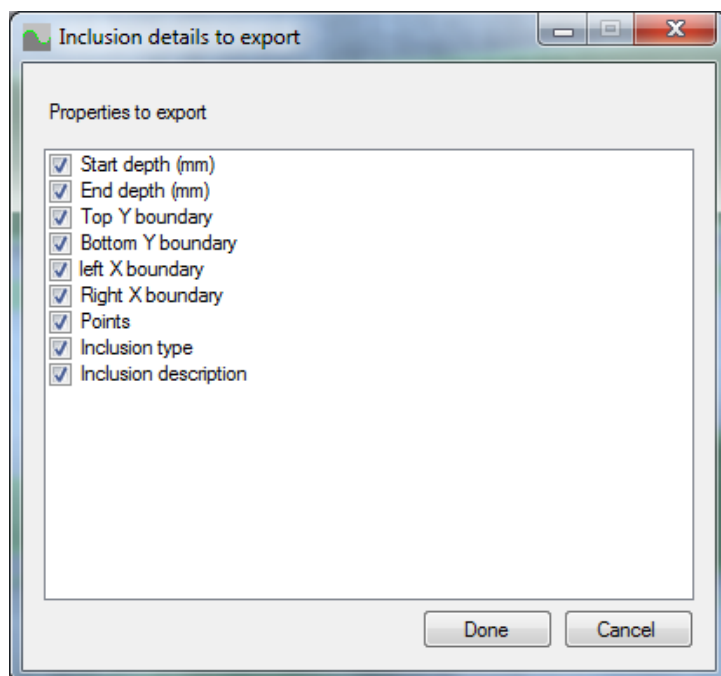**Figure 21 Cluster details to export.**

Figure 22 Inclusion details to export.

4.3 Depth/Luminosity profile

A luminosity profile of the borehole/core can also be created and written to an Excel or text file. The depth/luminosity profile gives a row-by row average of brightness intensity for the entire image. To create a depth/luminosity profile from the menu bar select "Tools>Create depth/luminosity profile>" then select either "Write to Excel" or "Write to text file." This will open the Create depth/luminosity profile window (Figure 23) where a number of options are available.

The sample rate can be modified so that the average luminosity is not taken at every row but instead at a specified distance.

It is also possible to remove certain features from the profile so that, for example, a background only profile can be exported, or a profile including just annual layering.
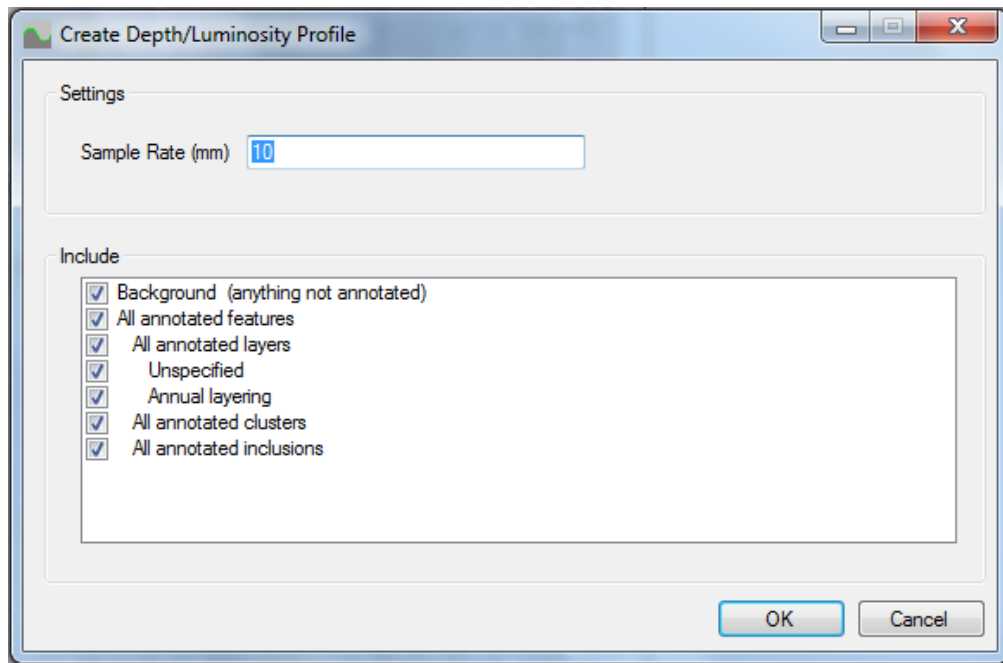
Figure 23 The depth/luminosity profile creation window

5 Troubleshooting

5.1 Folder Permissions

In windows 7 it is sometimes necessary to allow programs access to the folders that are being worked on. If BIFAT has difficulty saving projects, right-click the project folder and select properties. Select the "Security" tab and click the "Edit…" button. Make sure that the current user has acces to "Write" and "Modify" the current folder. If not select the tick boxes and click the "Apply" button.

5.2 .NET Framework Initialization Error

To run BIFAT an up-to-date version of the .NET framework must be installed on the machine. If this is not the case an error message (Figure 24) may be displayed when attempting to start the software.
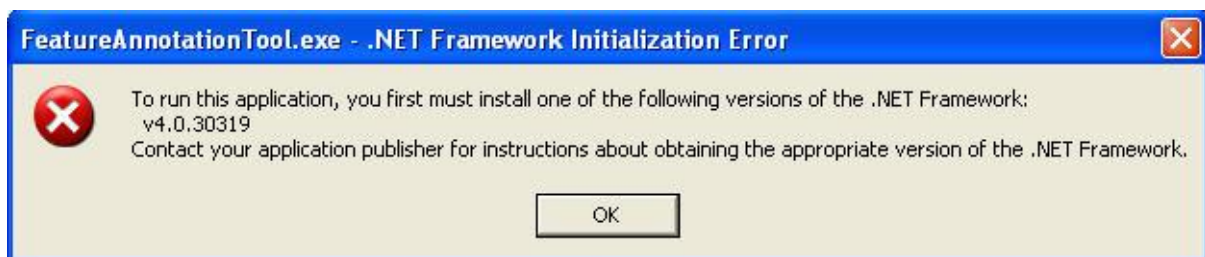

Figure 24 .NET Framework Initialization Error

The latest version of the .NET Framework can be obtained for free from
http://www.microsoft.com/en-us/download/details.aspx?displaylang=en&id=17851

For further support or to report any bugs please send an email to Terry Malone at trm8@aber.ac.uk, giving as much detail as possible regarding the issue.